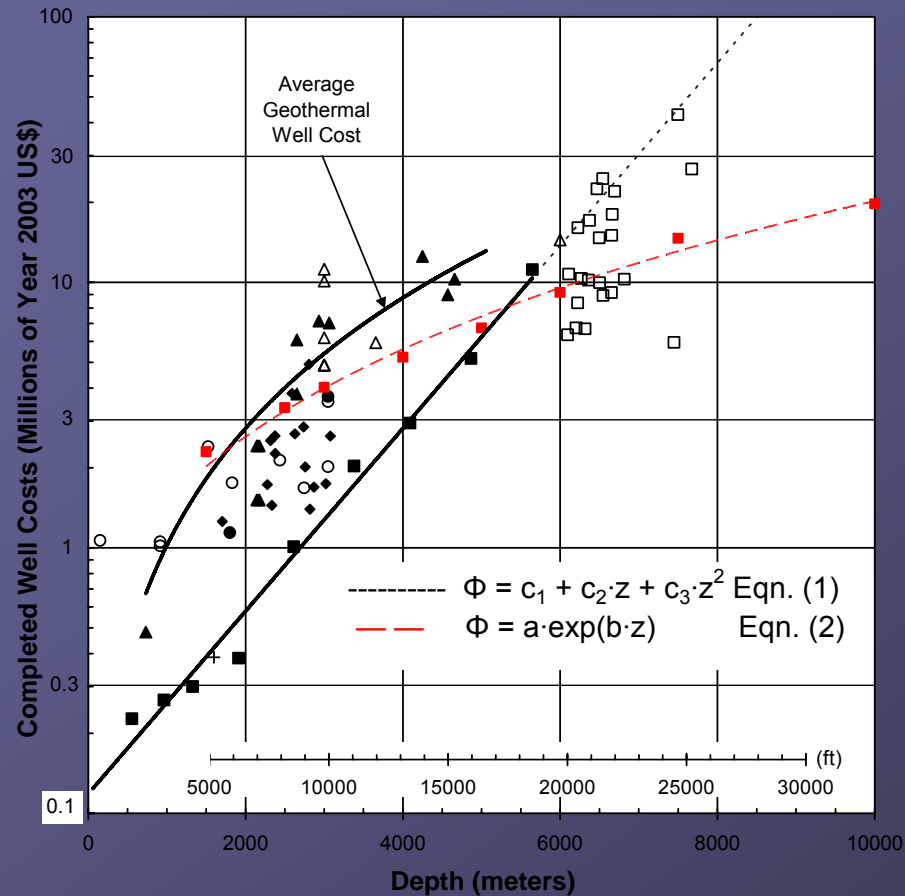# Wellcost considerations

Bill Livesay

History of well cost models
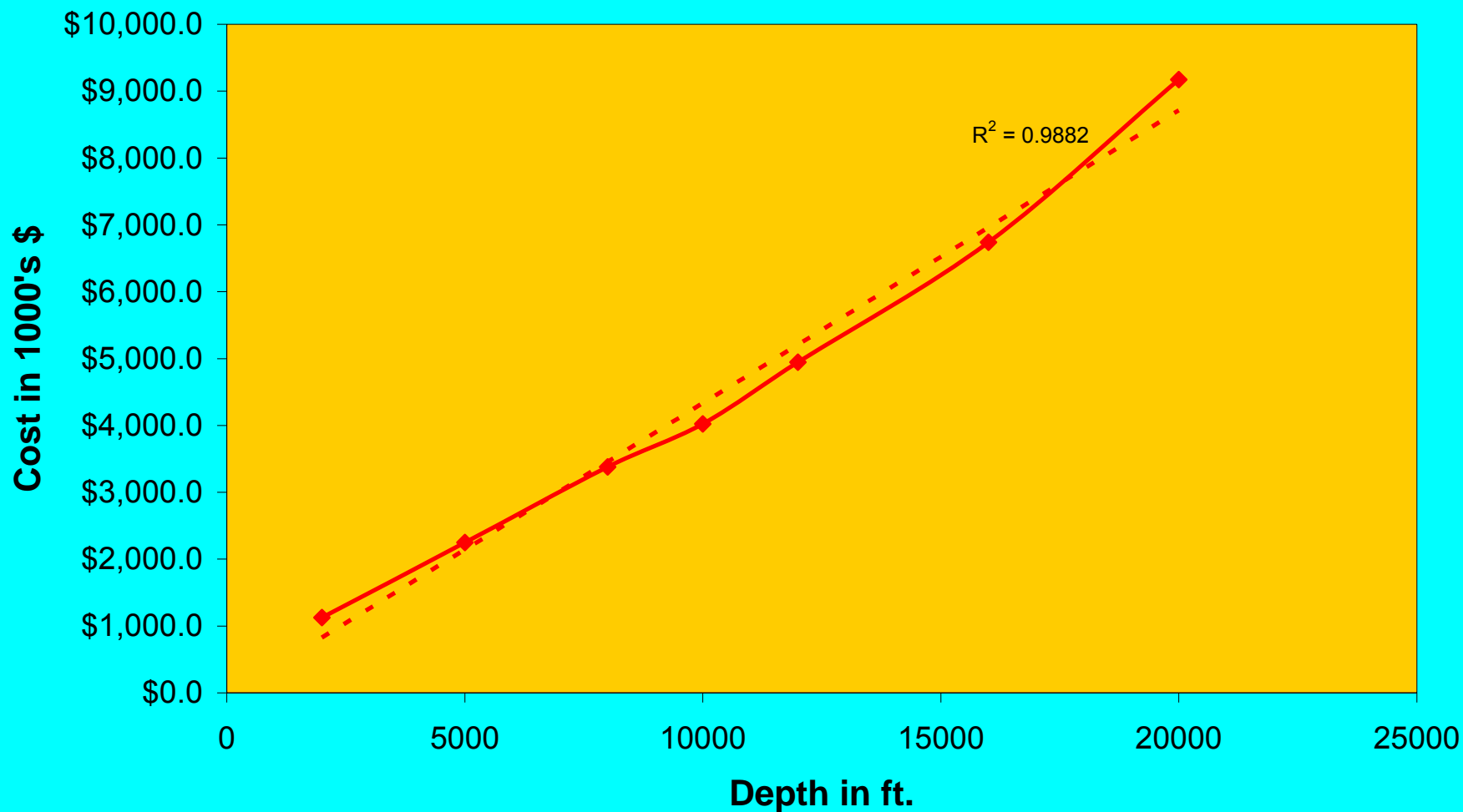
- Eight Generic Geothermal Wells
- IMGEO
- Simplified Wellcost routine
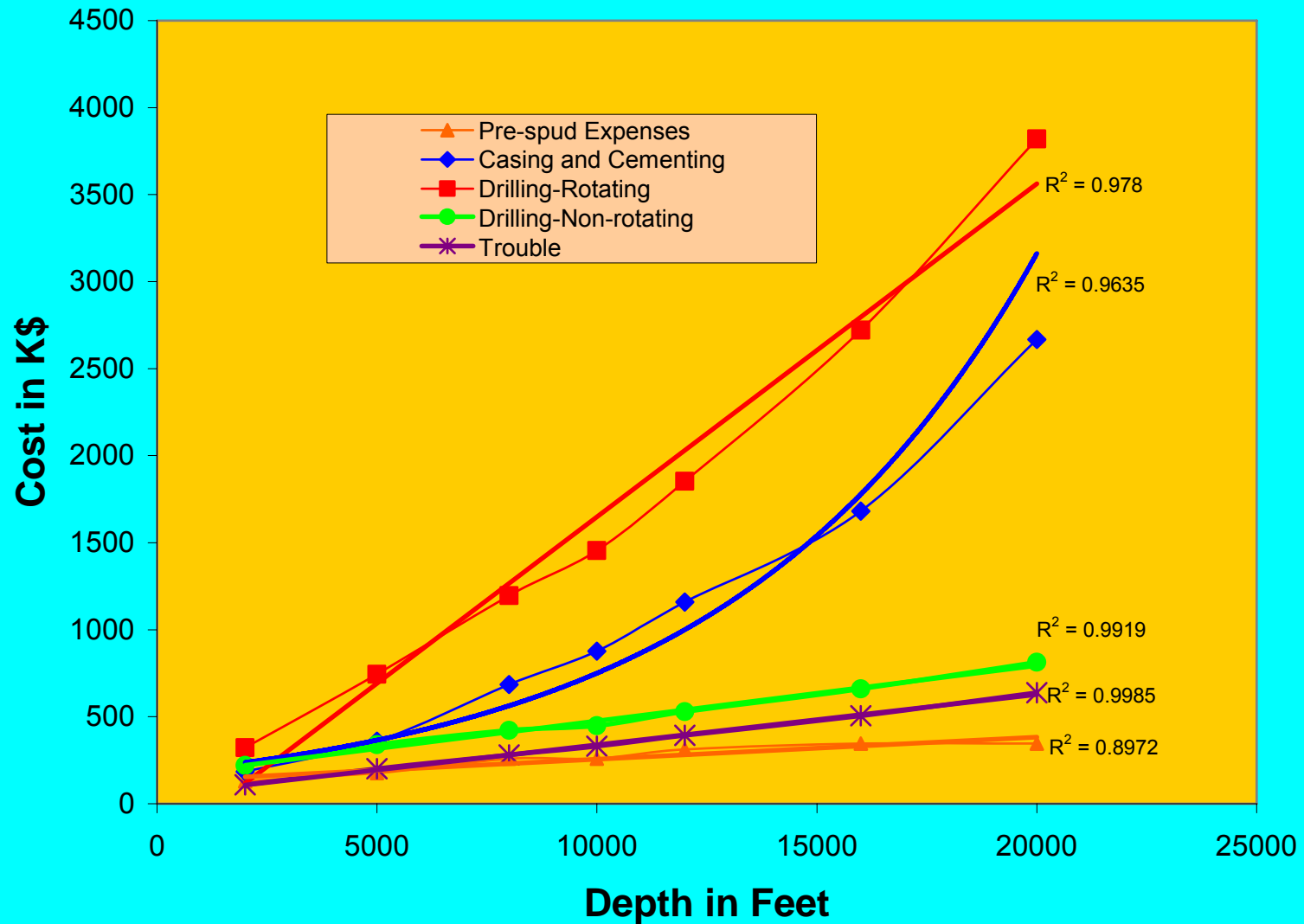- Wellcost 1996
- WellCost Lite
- Sub-models

Average Geothermal Well Cost

$$\Phi = c_1 + c_2 \cdot z + c_3 \cdot z^2 \quad \text{Eqn. (1)}$$

$$\Phi = a \cdot \exp(b \cdot z) \qquad \text{Eqn. (2)}$$

Completed Well Costs (Millions of Year 2003 US$)

Depth (meters)

(ft)

■ JAS Oil and Gas Average   ● Geysers Actual
□ JAS Ultra Deep Oil and Gas   ○ Hydrothermal Predicted
▲ Hot Dry Rock (HDR) Actual   + Other Hydrothermal Actual
△ HDR Predicted   ◆ Geothermal Actual
■ WellCost Lite Model

1. JAS = *Joint Association Survey on Drilling Costs*.
2. Well costs updated to US$ (yr. 2003) using index made from 3-year moving
   average for each depth interval listed in JAS (1976-2003) for onshore, completed
   US oil and gas wells. A 17% inflation rate was assumed for years pre-1976.
3. Ultra deep well data points for depth greater than 6 km are either individual wells
   or averages from a small number of wells listed in JAS (1994-2002).
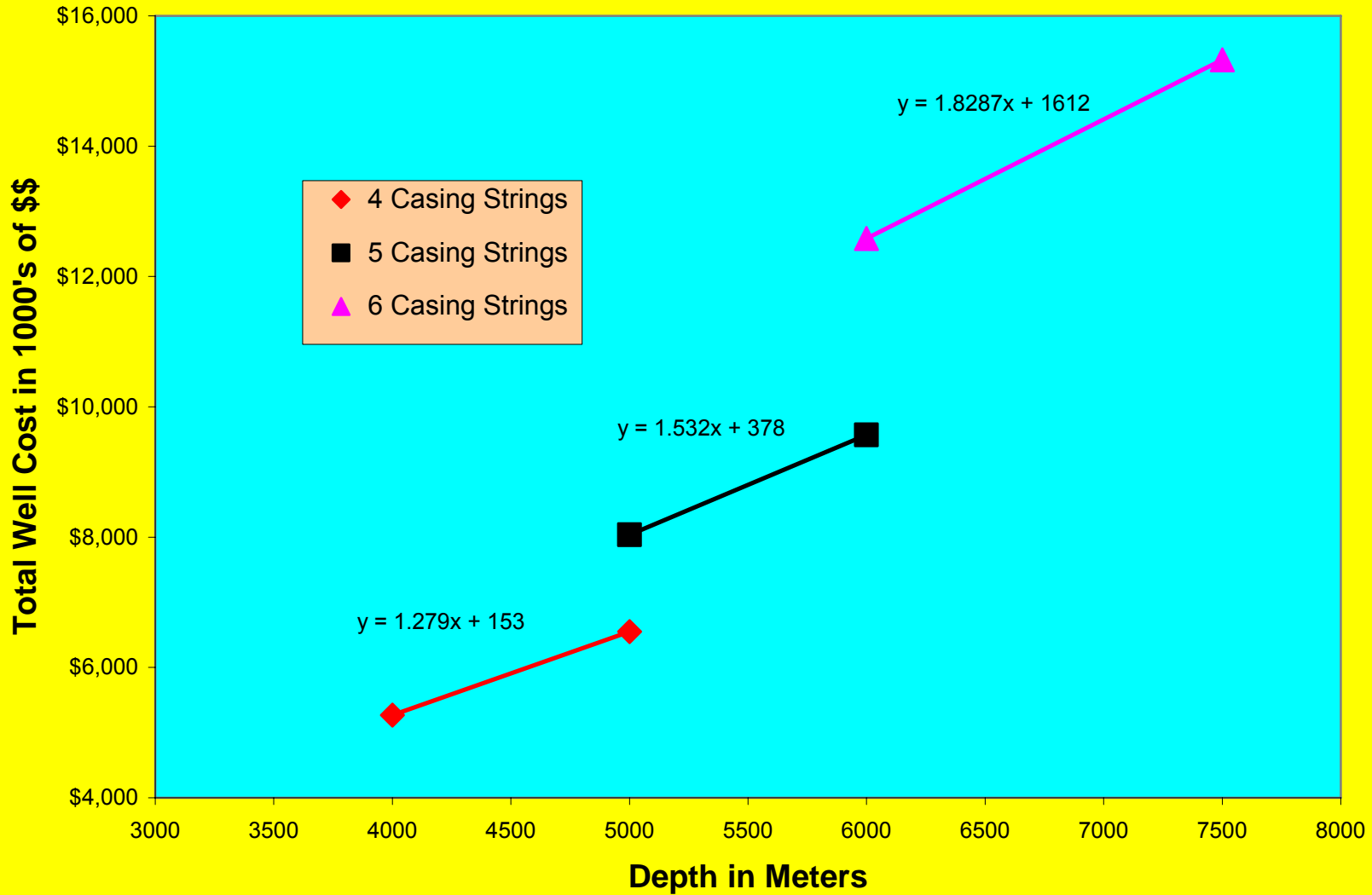4. "Geothermal Actual" data include some non-US wells (Mansure, 2004)

Total Cost of Drilling for Geothermal Wells Costed Using WellCost Model

**Drilling Cost Elements with Depth**

Legend:
- Pre-spud Expenses
- Casing and Cementing
- Drilling-Rotating
- Drilling-Non-rotating
- Trouble

$R^2 = 0.978$

$R^2 = 0.9635$

$R^2 = 0.9919$

$R^2 = 0.9985$

$R^2 = 0.8972$

Y-axis: Cost in K$

X-axis: Depth in Feet

Cost Variation with Addition of Extra Casing Strings

$16,000

$14,000

$12,000

$10,000

$8,000

$6,000

$4,000

Total Well Cost in 1000's of $$

Depth in Meters

3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000

- ◆ 4 Casing Strings
- ■ 5 Casing Strings
- ▲ 6 Casing Strings

$y = 1.8287x + 1612$

$y = 1.532x + 378$

$y = 1.279x + 153$

Wellcost issues

- Trouble costs
- Geological areas
- What should a geothermal well cost?
- Optimization concepts
- Comparison to Oil and Gas wells

Effect of ROP on Cost of Drilling
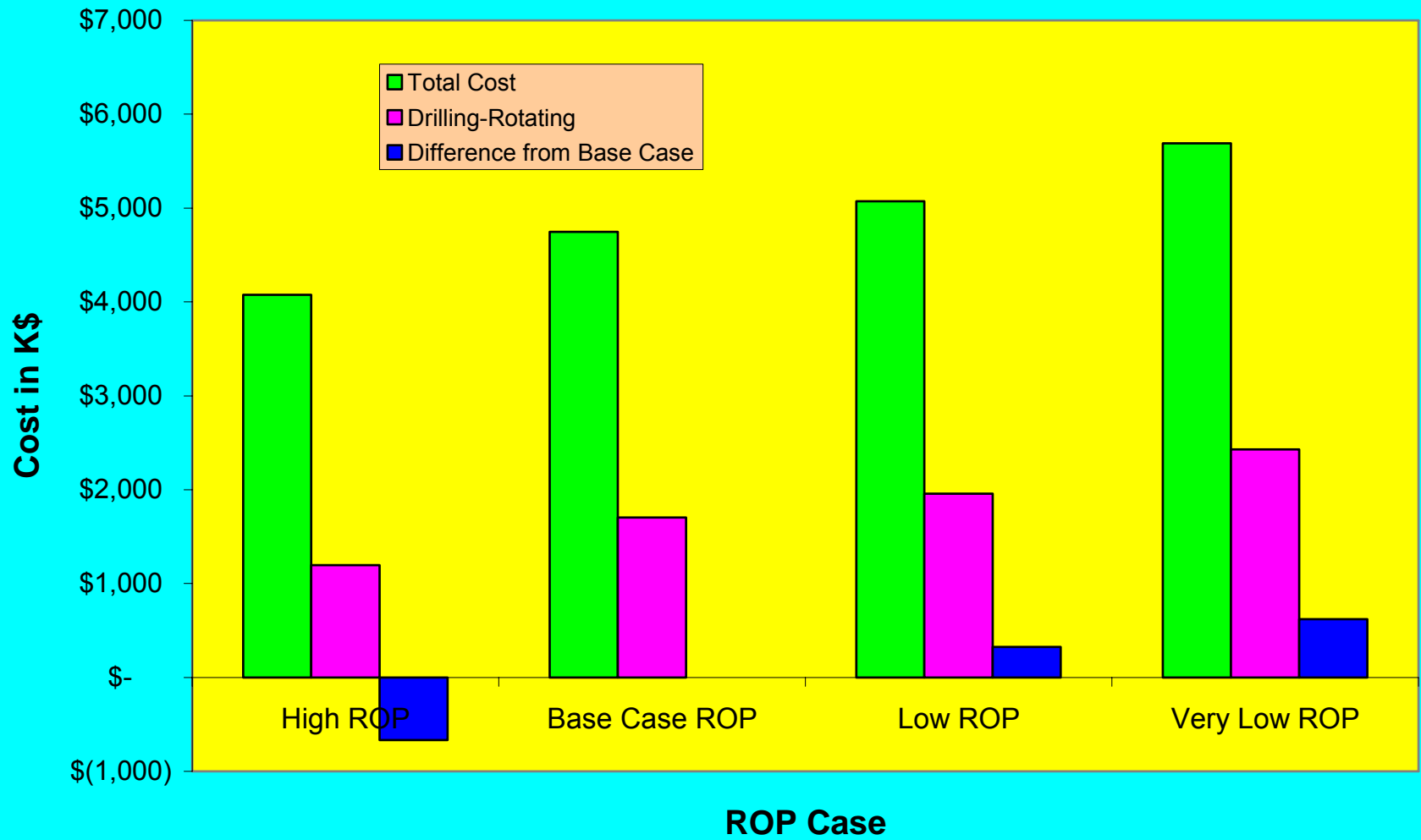
Variation of Production diameter

- Low temperature resources and EGS resources may require pumping
- Shaft drive pumps
- Electric submersibles
- Limitations
  - Shaft drive pumps
  - ESP pumping
- Other possibilities

Potential problems drilling in oil and gas areas

- Additional casing strings
- Well design
- Well control issues
- Fracture gradient
- Pore pressure variations
- Drilling fluid pressure
- Loss of hole

Trouble costs

- Lost circulation
  - Cost submodel
  - Frequency
- Stuck pipe and fishing
- Directional drilling
- Cementing failures
  - Squeezes
  - Top jobs
  - Tremmie pipe use
  - Twin streaming with Sodium Silicate

WellCost Lite

- Input pages
- Revised input pages
- Wellcost pages
- AFE pages
- Description pages
- Alternative outputs

AFE pages

- Similar to company planning document
- Totals with and without contingency
- Transferred to description page